FILM WINDING METHOD AND APPARATUS, AND LAY-ON ROLL FOR THE FILM WINDING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a film winding method and apparatus, and a lay-on roll for the film winding apparatus. More particularly, the present invention relates to a film winding method and apparatus suitable for efficient production of a film roll without degrading polymer film, and a lay-on roll for the film winding apparatus.

2. Description Related to the Prior Art

Cellulose acetate film as a type of cellulose acylate films is widely used for various purposes, including an electronic display panel, a support of a photosensitive material, and other optical equipments. Because of great development in techniques in the field of the electronic display panel, further reduction in the thickness of polymer film has been desired in the industrial use. So higher productivity of the polymer film is required.

In general, the cellulose acylate film is manufactured by a method of solution casting film forming. According to this, cellulose acylate is dissolved in solvent with additives including plasticizer, ultraviolet absorber, and lubricant, to obtain high-density solution. The solution is caused through a die to flow to an endless support such as a band, a drum or the like. The solvent is dried and

hardened, and removed from the support. Furthermore, the solvent is dried to obtain the polymer film.

According to considerable highness in the producing speed, stable winding in a station for the winding the polymer film becomes more difficult because of air between turns. Occurrence of inclusion of air between turns is likely to create low tightness in the winding, sinking failure and other failures. The term of the low tightness in the winding or looseness is used to refer to a failure of an excessively great difference between upper and lower radii of a film roll. The term of the sinking failure is used to refer to an accidental sink or recess in an upside of the film roll. This difficulty is specifically frequent in the case of a very high producing speed, or a very small thickness of the polymer film.

JP-A 2002-068538 discloses elimination of air from between turns of the polymer film. In winding the polymer film, a lay-on roll is used to press the polymer film toward a spindle for the film roll. According to this, it is possible to produce the film roll with regularly thick air layers between the turns of the polymer film.

However, the use of the lay-on roll electrifies the polymer film being wound because of the contact and separation between the polymer film and the lay-on roll. Foreign material or particles flowing in air are attracted by electrostatic charge. So failure of foreign material is likely to occur. Also, a voltage application type of static eliminator for the polymer film is used to generate ion, which is applied to the film roll as a product so as to eliminate static charge. However, this method has a problem in creation of gas of ozone in a winding chamber in the film winding apparatus. The ozone seriously degrades

the surface material of rubber in the lay-on roll. This causes an increase in the volume resistivity of the rubber surface. The amount of electrification rises. Also, black belt-shaped failure occurs, in which a surface of the film roll comes to have failure in deformation of the base in a belt shape of the black color in a circumferential direction of the film roll. This is because of rise in the hardness of the rubber.

SUMMARY OF THE INVENTION

In view of the foregoing problems, an object of the present invention is to provide a film winding method and apparatus in which electrification due to a lay-on roll in winding polymer film is suppressed, a status of a film roll in high-speed production is stabilized, and the polymer film can be produced with high quality and with high reliability.

In order to achieve the above and other objects and advantages of this invention, a film winding method includes a step of winding continuous polymer film being supplied into a form of a film roll. During the winding step, looseness of outer turns of the film roll is prevented by pressing a rotatable lay-on roll against the film roll. The lay-on roll includes a surface material, formed in a cylindrical shape, for contacting the film roll, wherein the surface material includes rubber, has volume resistivity of 10^2-10^{12} Ωcm, and hardness of 30-70.

The lay-on roll further includes a roll body about which the surface material is wound in a cylindrical form.

The roll body is formed from metal.

Preferably, the surface material has the volume resistivity of 10^4-10^8 Ωcm.

Preferably, the surface material has the hardness of 30-60.

The surface material has high resistance to ozone.

A winding speed of the polymer film in the winding step is 30 meters per minute or more.

The polymer film has a thickness of 125 microns or less during the winding step.

Preferably, the polymer film has the thickness of 85 microns or less during the winding step.

A pressing force of the lay-on roll to the film roll in the preventing step is 10-100 N.

Preferably, the pressing force is 20-80 N.

The pressing force is decreased in a range from 60 N down to 30 N according to an increase in a radius of the film roll.

The polymer film is cellulose acylate or polyester.

The surface material further includes carbon.

The polymer film has a width of 600-3,500 mm.

A length of winding of the polymer film into the film roll is 500-10,000 meters.

According to one aspect of the invention, a lay-on roll for a film winding apparatus winds continuous polymer film being supplied into a form of a film roll, the lay-on roll being rotatable, and pressed against the film roll while the polymer film is wound by the film winding apparatus, for preventing looseness of outer turns of the film roll. The lay-on roll includes a surface material,

formed in a cylindrical shape, for contacting the film roll, wherein the surface material includes rubber, has volume resistivity of 10^2-10^{12} Ωcm, and hardness of 30-70.

According to another aspect of the invention, a film winding apparatus includes a spindle for winding continuous polymer film being supplied into a form of a film roll thereabout. A rotatable lay-on roll is pressed against the film roll while the polymer film is wound about the spindle, for preventing looseness of outer turns of the film roll. The lay-on roll includes a surface material, formed in a cylindrical shape, for contacting the film roll, wherein the surface material includes rubber, has volume resistivity of 10^2-10^{12} Ωcm, and hardness of 30-70.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more apparent from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is an explanatory view in elevation, illustrating a film winding apparatus;

Fig. 2 is a front elevation, partially broken, illustrating a lay-on roll in the film winding apparatus;

Fig. 3 is a side elevation illustrating a film roll;

Fig. 4A is a perspective illustrating a state of a film roll having a sinking failure;

Fig. 4B is a front elevation illustrating the same as Fig. 4A; and

Fig. 5 is a front elevation illustrating a state of a film roll having a belt-shaped failure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S) OF THE PRESENT INVENTION

In Fig. 1, a film winding apparatus of the invention is illustrated. A spindle 10 is incorporated in the film winding apparatus. A motor (not shown) causes the spindle 10 to rotate. A supply unit supplies continuous polymer film 11, which the spindle 10 winds, to form a film roll 12.

A lay-on roll 13 is disposed in a rotatable manner, and positioned to contact the film roll 12. A pressing mechanism 14 presses the polymer film 11 toward the spindle 10. In the course of winding of the polymer film 11, air is removed from between turns of the polymer film 11. The film roll 12 can be formed with regularly thick air layers between the turns of the polymer film 11.

In Fig. 2, the lay-on roll 13 is constituted by a roll body 13a and a surface material or liner material 13b overlaid on the periphery of the roll body 13a in a cylindrical form. The roll body 13a is formed from metal, of which examples are SS, SUS and the like. An example of the surface material 13b is NBR rubber. Additive agent is mixed in the surface material 13b to impart rubber hardness of 40, and volume resistivity of 10^8 Ωcm. An example of the lay-on roll 13 having the surface material 13b of this characteristic is White EC 240NS, manufactured by Katsura Roller Mfg. Co., Ltd. Note that the rubber hardness is measured according to JIS K6253, and that the volume resistivity is measured according to JIS K6271.

The surface material 13b in the lay-on roll 13 has the volume resistivity in a range from 10^2 Ωcm to 10^{12} Ωcm, and

preferably in a range from 10^4 Ωcm to 10^8 Ωcm. Also, the surface material 13b has the rubber hardness of 30-60, and preferably 35-50. Furthermore, the surface material 13b is formed from a material having high resistance to ozone.

A preferable winding speed of the polymer film 11 is 30 or more meters per minute. The thickness of the polymer film 11 while wound is 125 microns or less, which is very preferable in view of the effect of the invention because of low rigidity and easy deformation. The thickness of the polymer film 11 while wound is preferably 85 microns or less, and desirably 65 microns or less. A pressing force applied by the lay-on roll 13 to the polymer film 11 when the polymer film 11 is wound is 20-80 N, and desirably 30-60 N. It is also preferable to change the pressing force of the lay-on roll 13 from 60 N down to 30 N according to the change in the diameter of the film roll 12.

The lay-on roll 13 can have any suitable shape. For example, the lay-on roll 13 may have an inclined portion or tapered portion. It is preferable also in this structure to set the pressing force between the polymer film 11 and the lay-on roll 13 in a range of 30-60 N.

The polymer film 11 used in the invention may be any suitable type. Examples of the polymer film 11 are plastic materials, which are cellulose acetates, such as cellulose triacetate, and polyesters, such as polyethylene terephthalate and polyethylene naphthalate. When the film roll 12 as a product is obtained, a width of the film roll 12 is 600-3,500 mm, preferably 1,000-1,600 mm. A thickness of the polymer film 11 in the film roll 12 is 25-250 microns, preferably 30-100 microns. A winding length of the film roll 12 is 500-10,000 meters, preferably 2,000-6,000 meters.

Both selvedge portions of the polymer film 11 to be wound is provided with knurling constituted by projections or recesses known in the art. Shapes of the knurling can be varied in a suitable manner.

Examples of the invention are hereinafter described. Of course, modifications are possible in relation to the preferred examples of the invention.

[Example 1]

In the film winding apparatus of Fig. 1, cellulose acetate film as the polymer film 11 was wound by use of the lay-on roll 13. The cellulose acetate film was wound at a winding speed of 35 meters per minute. The cellulose acetate film was 40 microns thick and 1,336 mm wide. The pressing force of the lay-on roll 13 was 35 N. The surface material 13b of the lay-on roll 13 was NBR rubber, which was White EC 240NS (trade name), manufactured by Katsura Roller Mfg. Co., Ltd., with rubber hardness of 40, and volume resistivity of 10^8 Ωcm.

[Example 2]

The surface material 13b of the lay-on roll 13 was NBR rubber in which carbon was added. The NBR rubber was 37H50S (trade name), manufactured by Kinyosha Co., Ltd., with rubber hardness of 50, and volume resistivity of 10^5 Ωcm. Except for this feature, the characteristics of Example 2 were the same as those of Example 1.

[Comparative example 1]

The surface material 13b of the lay-on roll 13 was NBR rubber without carbon. The NBR rubber was 31G40W (trade name), manufactured by Kinyosha Co., Ltd., with rubber hardness of 40, and volume resistivity of 10^{16} Ωcm. Except

for this feature, the characteristics of Comparative example 1 were the same as those of Example 1.

[Comparative example 2]

The surface material 13b of the lay-on roll 13 was NBR rubber in which carbon was added. The NBR rubber was 37H80S (trade name), manufactured by Kinyosha Co., Ltd., with rubber hardness of 80, and volume resistivity of 10^5 Ωcm. Except for this feature, the characteristics of Comparative example 2 were the same as those of Example 1.

[Comparative example 3]

The lay-on roll 13 was not used. Except for this feature, the characteristics of Comparative example 3 were the same as those of Example 1.

[Evaluation of the film roll]

The film roll 12 according to Examples 1 and 2 and Comparative examples 1, 2 and 3 was prepared. The polymer film 11 was cellulose acetate film. The film roll 12 was evaluated for the quality in relation to the electrification, the tightness in winding, the sinking failure, the black belt-shaped failure, the deposition of foreign material, the degradation of the lay-on roll 13.

[Evaluation of electrification]

To measure an amount of electrification, an electrostatic tester STATIRON-DZ3 (trade name) manufactured by Shishido Electrostatic, Ltd was used. Note that the film roll 12 is the better according to the smallness of the electrification. According to measured results of amounts of electrification, evaluation was conducted according to the ranks in Table 1.

TABLE 1

Electrification	Results
Lower than ± 1.0 kV	AA
± 1.0 kV or higher, and lower than ± 3.0 kV	A
± 3.0 kV or higher, and lower than ± 7.0 kV	B
± 7.0 kV or higher	F

[Evaluation of tightness in winding]

In Fig. 3, a film roll 20 had an upper radius LU of windings and a lower radius LD. To evaluate the tightness in turns being wound, a difference LD-LU between the radii LU and LD was calculated and evaluated. Note that the tightness of the film roll 12 is the higher and the better according to the smallness of the difference between the radii. According to measured results of the radius difference, evaluation was conducted according to the ranks in Table 2.

TABLE 2

Difference LD-LU between the two radii	Results
Less than 3 mm	A
3 mm or more, and less than 10 mm	B
10 mm or more	F

[Evaluation of sinking failure]

In Fig. 4A, it is likely that a sinking failure 22 occurs accidentally in a film roll 21. In Fig. 4B, a depth D1 of the sinking failure 22 was measured to evaluate the sinking failure 22. The depth D1 was defined as a distance between a deepest position of a sunken surface of the sinking failure 22 and a position of a normal surface without a sink as indicated by the phantom line. Note that the film roll 21 is the better according to the smallness

of the depth D1 of the sinking failure 22. According to measured results of the depth D1 of the sinking failure 22, evaluation was conducted according to the ranks in Table 3.

TABLE 3

Depth of the sinking failure 22	Results
Less than 3 mm	A
3 mm or more, and less than 10 mm	B
10 mm or more	F

[Evaluation of black belt-shaped failure]

In Fig. 5, a film roll 25 was inspected by human eyes for occurrence of a belt-shaped failure 26 in a black color. Evaluation was conducted as to existence or lack of the belt-shaped failure 26. Note that the film roll 25 without the belt-shaped failure 26 is desired.

[Evaluation of deposition of foreign material]

Stroboscopic light was applied to the outermost turn of the film roll 12. The number of particles as foreign material on the one outermost turn of the film roll 12 were inspected by human eyes. Preference is higher according to the highness of the number of particles. According to measured results of the numbers of the particles, evaluation was conducted according to the ranks in Table 4.

TABLE 4

No. of particles as foreign material	Results
0-2	AA
3-5	A
6-10	B
11 or more	F

[Evaluation of degradation of the lay-on roll]

Regarding degradation of the lay-on roll 13, it was checked whether cracks had occurred in the lay-on roll 13 after the use for one month. It was also checked whether the belt-shaped failure had occurred in the film roll 12 after the use of the lay-on roll 13 for six months. Evaluation was conducted according to the existence or lack of the cracks and the belt-shaped failure. Note that the evaluation of the ozone degradation of the rubber was according to JIS K6259 in conditions of the ozone density of 50 pphm (parts per hundred million), temperature of 40°C, and exposure time of 48 hours. However, in the process of the present evaluation, existence or lack of cracks was evaluated after the use for one month. Note that the preference is higher when no cracks and no belt-shaped failure occurs.

[Total evaluation of the film roll]

The film roll 12 according to Examples 1 and 2 and Comparative examples 1, 2 and 3 was observed and evaluated for the above-described items, to obtain the following results.

TABLE 5	Ex. 1	Ex. 2	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
Electrification	A	AA	F	AA	A
Tightness in winding	A	A	A	B	F
Sinking failure	A	A	A	B	F
Black belt-shaped failure	None	None	None	Found	None
Deposition of foreign material	A	A	F	A	A

Degradation of the lay-on roll	None	Found	Found	Found	--

In Example 1, good results were obtained for all of the items of the evaluation. In Example 2, the lay-on roll was degraded. The black belt-shaped failure occurred after the long use. However, it is concluded that the film roll 12 can be formed by Example 2 if the long use is avoided. In contrast, no good results for the film roll 12 were obtained from Comparative Examples 1-3.

Although the present invention has been fully described by way of the preferred embodiments thereof with reference to the accompanying drawings, various changes and modifications will be apparent to those having skill in this field. Therefore, unless otherwise these changes and modifications depart from the scope of the present invention, they should be construed as included therein.